ART. IV.—A CASE OF PROGRESSIVE MUSCULAR ATROPHY WITH SCLEROSIS OF THE LATERAL COLUMNS.

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THE following case is of interest in its relation to the pathology of progressive muscular atrophy, and also in view of the recent division made by Prof. Charcot of this disease into two groups. I have to thank my friend Dr. B. A. Segur for the opportunity of seeing this patient. The first part of the case was observed by him, the latter part by me.

Male, aged 44, with apparently no neurotic family history; at 20 years of age he had gonorrhœa, followed by stricture, gleet and its accompanying pain in back, hips, &c., but otherwise he enjoyed good health. In 1870, his first impairment of health began; in February of this year, after an exposure to wet and cold, he became quite sick, the exact nature of which sickness is not known; it was of such a nature, however, as to confine him to his room for two and a half months, and he was unable to engage in any occupation for one year after; he thinks he never entirely recovered his former vigor; following this he had some pulmonary hemorrhage and expectoration, which was slight. In October, 1875, the first symptoms of his present difficulty appeared; he began to notice fibrillary twitchings in the small muscles of hands, especially those of the thumb, and simultaneously there was a wasting of these muscles, their function was also impaired, as shown by inability to tear up pieces of paper, &c., which is done by the index and thumb; the condition was alike in both hands. The atrophy went on so rapidly in the muscles of the hands that in January, 1876, he was unable to write; the atrophy and fibrillary twitchings then began in the muscles of the arm and forearm. He began to have bulbar symptoms about May of this year, and by October the glosso-laryngeal paraly-

sis was quite marked, and his speech was almost unintelligible; at this time he was also unable to walk with his accustomed firmness, tiring easily.

I first observed him in May, 1877, when his condition was as follows: Unable to utter a word, could make simply a grunt, tongue immovable in floor of buccal cavity, a mass of furrows and wrinkles, and the seat of continuous fibrillary contractions; he has the remains of a harelip, a good deal of difficulty in swallowing, upper extremities and chest a skeleton, the muscular atrophy has become so great arms hang by his side quite flaccid and limp, no contracture present, fibrillary contractions wherever there is any muscular tissue left, lower extremities in good condition to inspection, patient can stand and walk but is easily fatigued, no anæsthesia, no rectal or vesical difficulty, the atrophied muscles are the seat of soreness, and when the muscles are pressed or stretched it causes discomfort and pain; what muscular tissue is left reacts normally to faradism; this condition advanced, and the lower extremities began to atrophy rapidly, and in the middle of August, 1877, he was unable to stand, and had to keep his bed; he existed in the most deplorable and helpless condition until September 27, 1877, when he died, evidently from exhaustion and the bulbar disease.

Post-mortem twelve hours after death. Unfortunately I had to make the examination in a great hurry. The spinal cord and the brain were the only parts examined by me. I regret not having been able to examine the peripheral nerves and the muscles. The pectoral muscle was the only one examined; to the naked eye it had a pale appearance, what was left of it; the cerebrum to the naked eye presented nothing abnormal; the spinal cord also showed nothing unusual when intact, but when transverse sections were made in it at various points previous to hardening, the grey matter was seen to be much more vascular than normal; the anterior nerves were apparently not diminished in size, but presented an unusual translucent appearance.

Histology. Specimens hardened in solution bichromate potassa; the cord was divided into fifteen segments of about equal length, and transverse sections made from each of these

segments; stained in carmine and extractum hæmatoxyli and mounted in Canada balsam after Lockhart Clark's method.

The cervical region was the point at which the disease began, and was examined first; here the morbid changes were of a very marked character; examination of the sections made from other regions (of the cord) soon showed that the changes which had taken place were identical throughout the cord, but differing in degree and in some minor respects, but differing in such a manner as to render important aid in the interpretation of some of the points in the pathological physiology of the case, and in the sequence of the pathological changes which are seen to be present. Two very decided pathologic changes are seen in the cord:

1st. Atrophy of the ganglion cells in the anterior horn.

2d. Sclerosis of the lateral columns.

The atrophy of the ganglion cells of the anterior horn in the cervical enlargement is very nearly complete. In almost every section nothing is to be seen but a very small mass of yellowish brown pigment, here and there, occupying the place of the cell. In only one section from this region did I find a cell in fair preservation; but without any processes, and containing a considerable amount of pigment, but having a nucleus and a fair amount of protoplasm around it sharply stained by the carmine.

In the dorsal region the cells are almost as much atrophied, but as you pass down to the lower dorsal region you find more and more cells in a fair degree of preservation; none, however, in a normal condition. In the lumbar region, the largest amount of cells are to be seen, and in some places the number is almost normal, but there is not one cell which has not been affected; the pigmentation, atrophy and the absence of processes are the characteristic changes in these cells; the pigmentation takes place in the body of the cell, usually at one edge, and encroaches upon the nucleus; the pigment is of a yellowish brown color; the atrophy of the processes appears to come about in an entirely different way, they become more and more translucent and attenuated, and at last melt away, from the distal end first, without any more positive change, and they refuse to take up the carmine; this method of disap-

pearance of the processes gives a peculiar appearance to the stump; it looks as if the process was cut off somewhat abruptly, not sufficiently so, however, but as to leave behind a vestige of the process, showing this peculiar translucent appearance, which, in some cells, contrasts very decidedly with the thick, sharply stained body of the cell; it would appear that all the processes do not undergo this mode of change, for occasionally there is to be seen in the grey matter of the anterior horn a few processes in fair condition, which evidently have been cut loose by the section knife; these, however, are very few.

The sclerosis of the lateral columns is most intense in the cervical enlargement, and becomes less so as we go down to the end of the cord; the accompanying wood-cuts show the distribution of the sclerosed area; it differs greatly in the different regions; the sclerosis is of a very light character throughout the cord; it is a very limited region in which the nerve tubes are much altered; the nerve tubes in the sclerosed region have simply become a little smaller, have a cloudy appearance and a tendency to run together, and a light granular material around them; the septa running between the nerve bundles are a trifle thicker, and, therefore, appear more numerous in this region, and take up the carmine staining very sharply, so that to the naked eye the sclerosed region appears more diseased than microscopic examination shows it to be in those sections; from the cervical enlargement quite a number of spider cells are to be seen, similar to those described by several authors in various pathological conditions of the nervous system, also by Dr. E. C. Seguin and myself in disseminated cerebro-spinal sclerosis;* but they are quite small; in the other regions there appears to be very little change in the neuroglia cells; there is an increase of blood-vessels in the diseased regions, grey as well as white matter; everywhere the blood-vessels appear normal. In the cervical region the central arteries are surrounded by, and their perivascular spaces distended with an opaque material which is

*"A Contribution to the Pathological Anatomy of Disseminated Cerebro-Spinal Sclerosis," Drs. E. C. Seguin, J. C. Shaw, and A. Van Derveer, JOURNAL OF NERVOUS AND MENTAL DISEASE, April, 1878.

lightly stained by hæmatoxylin, and which I take to be an exudated fluid of some kind, albuminous probably, and which has become coagulated; moreover, there is a cloudy appearance in the entire diseased area in this region, grey as well as white matter, and which is evidently due to an infiltration of the same kind of material; the question of its being a defect in the method of preparation was soon settled by making many sections in different ways, and the additional facts that in the same section those parts of the cord remaining normal were not in the least cloudy, and that the dorsal and lumbar regions prepared in the same way, did not present the same appearance. Sections made very near together, through the decussation and into the medulla, showed that the sclerosis extended into the anterior pyramids of the medulla; but the sclerosis became more and more light until, in sections made through the middle of the olivary bodies, it was a very difficult matter to tell if there was any sclerosis present; but after making a great number of sections through the decussation so as to find where the sclerosis ceased, and, after a most careful examination of all the specimens in their order, I was able to satisfy myself that there is a very slight sclerosis here, and that it has been growing less and less intense up to this region; but I was also able to determine that there is a slight sclerosis in this region (sections through middle of olivary bodies) in that part of the medulla which Meynert considers as belonging to the lateral columns of the cord (see Fig. 4, B), and that a very light fine strip extended from this down almost to the pyramids (see Fig. 4). Almost all the nerve cells in the nuclei of origin of nerves have suffered atrophy, the cells in the pneumogastric nucleus are wasted and indistinct, but the nucleus of the hypoglossus is where the disease is greatest, the cells have undergone extensive pigmentation and atrophy, not one nerve cell is to be seen with a process; the cells in the nucleus of the sixth and seventh nerves are in good condition.

Sections through the middle of pons and crura (left) shows nothing abnormal.

The pectoral muscle shows simple diminution in the size of the muscular fibrils, and nothing more.

The question immediately arises, what is the connection be-

tween the symptoms in this case and the pathologic changes found? Numerous cases have now been reported in support of the spinal origin of progressive muscular atrophy, and this case is an addition; this view we can now consider almost definitely settled; the myelitis of the anterior horn and disappearance of the ganglion cells explains the muscular atrophy; but as to the connection which the lateral sclerosis bears to the myelitis of the anterior horns and to the symptomatology we are still in doubt.

In recent years Prof. Charcot* has announced and taught that what has heretofore been called progressive muscular atrophy really comprehends two distinct diseases, having a special symptomatology and distinct pathological anatomy; a first form he calls progressive muscular atrophy protopathic (type Duchenne-Aran), a second form progressive muscular atrophy, deuteropathic or lateral amyotrophic sclerosis.

In the first form muscular atrophy is the first and predominant symptom, the disease lasts many years, and bulbar symptoms do not occur; myelitis of the anterior horns is the pathological condition; in the second form, first paralysis or paresis, then muscular atrophy and contracture, finally bulbar paralysis; the disease lasting about three years, with fatal termination; pathology, lateral sclerosis and secondary myelitis of the anterior horns.

Now what is my case, one of lateral amyotrophic sclerosis with bulbar paralysis?

Clinically, the contracture which Charcot appears to consider as constant is wanting, there is not even the least contracture in the hands, and the muscular atrophy here was certainly the first symptom; the rapidity of the case and the bulbar paralysis corresponds to the clinical picture given by Charcot of lateral amyotrophic sclerosis. Now, when we come to examine the cord there are what appear to be at first sight changes which place the case as one of lateral amyotrophic sclerosis, but a most careful study of the sections lead me to consder it otherwise.

These are my conclusions: the myelitis of the anterior horns (commencing in the cervical enlargement) was the primary lesion; the extent and severity of the lesion and the time of

**Archives de Physiologie*, 1875, and *Maladies du Systeme Nerveux*, Tome II.

appearance of the muscular atrophy lead me to this opinion; the lesion in the lower part of the cord and in the analogues of the anterior horns in the medulla was simply a matter of extension; the sclerosis of the lateral columns I look upon as entirely secondary, and rather as a form of secondary degeneration than a true sclerosis; I cannot conceive how a sclerosis of the lateral columns can exist for such a length of time (if it had been the primary lesion) and yet produce so slight an effect on the nerve tubes as was found to be the case here.

I have spoken of this condition of the lateral columns as sclerosis, because it has been so called by most observers, but to me this appears incorrect, for there certainly is a difference between this change and that which takes place in disseminated cerebro-spinal sclerosis, and to this latter condition would I restrict the word sclerosis as indicating peculiar, active, and primary changes in the neuroglia cells; the condition spoken of in this case is, as far as the neuroglia cells are concerned, comparatively a passive one, and resembles more the condition seen in so-called secondary degeneration due to primary brain lesion, where the nerve tubes appear to be the primary seat of trouble; the same appearance of the neuroglia cells is seen in the sclerosis of the posterior columns in locomotor ataxia, and is a different process from that in disseminated sclerosis.

The presence of contracture in these cases, as a symptom, which is always present and due to the sclerosis of the lateral columns, and which is one of the distinguishing points of this variety, as Charcot supposes, is certainly not correct. I have had the opportunity of seeing another case similar to this one which I describe (but in which I obtained no post-mortem). Here there was no contracture, and Prof. Leyden has recently recorded several cases* in which post-mortem showed, like my case, very light sclerosis of the lateral columns; contracture was absent in several of his cases. Leyden's cases, although beginning with bulbar symptoms, are evidently the same disease, having its origin in a different point of the cerebro-spinal axis.

* "Ueber progressive, amyotrophische Bulbarparalyse, etc." *Archiv fuer Psychiatrie und Nervenkrankheiten*, Band 8, heft 3.

The connection between the lesion in the grey matter and that in the lateral columns is one which has created much interest and some discussion. Charcot is the father of the view that in those cases which present the clinical history and symptomatology, as previously given, and in which microscopic examination has shown myelitis of the anterior horns and symmetrical lateral sclerosis, that the sclerosis is primary and the lesion of the anterior horn secondary. Upon this he has founded the disease, lateral amyotrophic sclerosis. This view of Charcot's has been pretty widely accepted, and recently Gombault* has published a monograph on the subject; it has, however, met with sharp criticism from many quarters, especially German neuropathologists. At this time it appears impossible to come to any very definite conclusion on the subject. Many more observations will have to be recorded before it is settled; this, however, is certain, that there are lesions of the grey anterior horns which will produce secondary lesions of the lateral columns. The idea that the lesion of the lateral columns is due to a bilateral lesion in the cerebrum is not confirmed, and appears, to say the least, rather doubtful. It is true, as Flechsig says, that the lesion is most intense in what he calls "Pyramidenbahnen" (at least it is so in my case), but it certainly is not equally intense throughout this bundle, but rather occupies the inner part of it; and the idea that the lesion shades off from this is to me incomprehensible, as the shading off, if it were so, goes almost entirely to the anterior white matter. The sclerosis being most intense in the cervical region, shows that it is not dependent upon lesion above the cord, and the fact that the sclerosis disappears in the medulla, supports this, and argues that it is dependent upon the myelitis of the anterior horn. I do not deny that there is a primary lateral sclerosis with secondary lesion of the anterior horns; but there are certainly cases running the course (about three years) having the symptomatology, bulbar paralysis, etc., of what Charcot calls lateral amyotrophic sclerosis, in which the symmetrical lateral sclerosis is not the primary lesion (my own and Leyden's cases).

Secondary changes are seen in the lateral white matter in

* *Etude sur le Sclerose laterale amyotrophique.* 1877.

cases of infantile spinal paralysis in which the lesion is an acute myelitis of the anterior horns. No special attention appears to have been paid to this condition, nor has the question arisen why it is there. It must be said that Charcot states that he has never seen a case in which the myelitis of the anterior horns caused secondary degeneration of the lateral columns, but he does not appear to think that it is impossible.

One point appears to me of great importance in the microscopic examination of these cases, and that is a careful observation and record of the degree of change in the different regions (anterior horns and lateral columns). The conclusion from all this is evident, that the symptomatology and the interpretation of the pathological changes seen in the so-called lateral amyotrophic sclerosis of Charcot will have to undergo modifications, and cannot be considered so absolute as Charcot has laid it down.

EXPLANATION OF WOOD-CUTS.

The shaded regions indicate the sclerosis.

Fig. 1.—From cervical enlargement, showing distribution of sclerosis in lateral white matter.

Fig. 2.—From dorsal region ; it will be observed that the sclerosis does not occupy exactly the same region as in Fig. 1, but keeps very near to the posterior horn. In some sections from this region the sclerosis extended pretty well forward, and as far as the anterior border of the anterior horn, and keeping close to the grey matter.

Fig. 3.—From lumbar region. Here the sclerosis is very limited in extent and is well indicated by wood-cut.

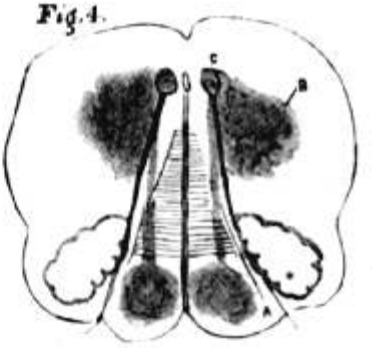
Fig. 4.—From section through middle of olivary bodies; here the sclerosis is of an exceeding slight character. Fig. *a*.—Sclerosed anterior pyramid. Fig. *c*.—Nucleus of hypoglossus. Fig. *b*.—Sclerosed region in district which Meynert considers as belonging to the lateral regions of the spinal cord; also a light band of sclerosis extending from this down almost to the sclerosed anterior pyramid.

Fig. 1

Fig. 2.

Fig. 3.

Fig. 4.



self-registering, and moderate pressure upon the bulb was found to elevate the registering column slightly over one degree. The necessary manipulation of the instruments, of which I shall speak presently, rendered these defects fatal to accuracy. This easy response to moderate pressure upon the bulb is, I am led to believe, a very general although unrecognized fault with thermometers of this variety. As a curiosity, I have brought one with me to-day, made by some foreign manufacturer, in which, as you see, pressure upon the bulb alters the scale 15 degrees. I rejected, therefore, the observations already made, and ordered a new set. After repeated and careful experimentation, Mr. A. Bayer, by whom these thermometers are made for Messrs. Tiemann & Co., succeeded in completing a set, in some of which moderate pressure had no appreciable effect, while in others such pressure would cause the scale to rise about one-fifth of one degree; and these were made self-registering. Before placing the thermometers in position, I have made a practice of shaking the register down 10 to 12 degrees below the probable temperature of the part to be registered, thereby avoiding all possible error from pressure. I have taken great care that these instruments should be also perfectly accurate as registers of heat. They were compared with a standard thermometer in the possession of Mr. Bayer, which had been seasoned for three years in the rough, then carefully and repeatedly graduated by a standard thermometer of Mr. James Green, the well-known maker of scientific apparatus, which latter is identical with Casella's standard; and from time to time since their manufacture my instruments have been again tested.

For holding the thermometer upon the head I employ a ribbon, such as is used for a laryngoscopic mirror, or a morocco band (Fig. 1), either of which is perforated throughout its length by holes of proper size to snugly embrace the tube. This ribbon or band encircling the head, upon a level with the eye-brows and the temporal plane just above the ears, and being buckled across the forehead, I station thermometers in it at the points indicated by M. Broca, as follows: One on each side somewhat back and above the commencement of the external angular process of the frontal bone, one on each side

just above the ear, and on each side of the occiput. The two anterior points I have termed the Frontal Stations, the two above the ear the Parietal Stations, and those posteriorly the Occipital Stations. In this manner the frontal, the parietal, and the occipital lobes are fairly approached. But these temperatures indicate only the temperature of the sides of the brain. It has seemed to me important, as well as feasible, that the temperature of the motor region of the vertex should also be ascertained. With this end in view, I have profited by the recent researches in cranial topography of MM. Broca,* Heftler,† and Féré.‡ According to these writers the fissure of Rolando, which may be regarded as at the centre of the motor region of the vertex, abuts upon the great longitudinal fissure at a distance of 47 to 48 millimetres, or about $1\frac{7}{8}$ inch, to the rear of the coronal suture. As the coronal suture, however, is not easy to distinguish through the scalp in the living person, I have selected the furrow formed by the junction of the nasal bones with the nasal process of the frontal as a more salient point of departure, and have determined its distance from the coronal suture by measurement of 24 skulls. The average was found to be 5 inches, the maximum $5\frac{3}{8}$ inches, the minimum $4\frac{5}{8}$ inches. This average, or a deviation from it of not more than $\frac{3}{8}$ of an inch, was maintained in 95.82 per cent. of the measurements. Adding together the calculations of the French authorities as to the distance of the fissure of Rolando from the coronal suture, and my own as to the distance of the coronal suture from the junction of the nasal bones with the frontal, the average distance of the fissure of Rolando from the fronto-nasal junction is ascertained to be about $6\frac{7}{8}$ inches, the deviation being so slight as to be practically of little moment. Mapping out the fissure of Rolando in this manner, I have attached by loops two ribbons or bands to the ribbon or band encircling the head, in such a manner that one may be

* "Sur la topographie crânio-cérébrale," *Rev. d'Anthrop.*, t. v., No. 2, 1876.

† "Circonvolutions cérébrales chez l'homme, et leurs rapports avec le crâne," par Ferd. Heftler, Dissert. Inaug. à l'Acad. Med.-Chir. de Saint-Petersbourg, 5 mai, 1873.

‡ "Note sur quelques points de la topographie cérébrale," par Ch. Féré. *Bull. Soc. Anat.*, 24 déc., 1875.

buckled across the vertex anteriorly and the other posteriorly to the fissure (Fig. 1). In each of these bands I station two thermometers, one on each side of the median line of the head, and about an inch apart, so that a square is thus formed, roughly tracing the outline of the motor zone of the vertex, and at whose four corners are situated the Vertical Stations. These bands or ribbons are of the same material as the lateral head-band, and similarly perforated.

FIG. 1.

HEAD-STRAP.

FIG. 2.

PAD.

FIG. 3.

THERMOMETER.

FIG. 4

FINGER.

The instruments have been carefully protected against atmospheric variations by a small silk pad lined with wool (Fig. 2), and which has an orifice so as to permit of its being slid over the tube down to the upper surface of the bulb, as well as by a silk finger (Fig. 4), also lined with wool, which is pushed over the tube.

It has been my habit to arrange the head-gear in this manner : I first buckle the band around the head. Sliding a pad over each thermometer, passing the tube through a perforation opposite the proper place, and then covering it with a silk finger, I adjust an instrument at each Frontal, Parietal, and Occipital Station. I now fasten the vertical bands in place, and, observing the same precaution as to pads and fingers, I arrange the four thermometers as I have described. The instruments remain on the head for twenty minutes; and then, gently and carefully removing the silk fingers, without at all moving the bulb from the scalp, I read off the markings.

M. Broca's observations were made on twelve internes and dressers, who were nearly of the same age, the same intellectual development, and placed very nearly in the same circumstances. For purely scientific or physiological purposes, this similarity of age, intellect, and surroundings, was undoubtedly of great advantage. From a utilitarian, diagnostic point of view, however, this feature is of equally great disadvantage, because it would be impracticable to select our patients so nicely and critically. At the outset, therefore, I resolved to take persons as they came, simply being careful to avoid any extremes, as of great emotion, mental excitement, or prolonged slumber, and that there should exist no appreciable ill-health. My observations were made upon 92 of the medical students in attendance at the Long Island College Hospital, as well as upon 10 physicians, numbering in all 102 males. The age has been on the average 28.94, the maximum 50, the minimum 18. Of this number I am unable to make use of 40 for absolutely accurate calculations, because of a defect in my thermometers of somewhat less than one-quarter of one degree, which was unnoticed for several days, and which I cannot eliminate in any other way than by this wholesale rejection. For calculations, however, that are merely comparative, and wherein this defect would be harmless, I shall employ these imperfect observations without hesitation. In all of my cases I have also taken the temperature of the mouth with an accurate thermometer. The Fahrenheit scale has been used in preference to the centigrade, as it is more familiar to Americans.

The average of the Left Frontal Station was 94.36°, that of the Right being 93.71°, the difference being .65°. At the Left Parietal the average was 94.44°, while at the Right it was 93.59°, the difference being .95°. The average of the Left Occipital Station was 92.66°, that of the Right 91.94°, showing a difference of .72°.

Thus, it will be perceived, the left lobes possess a higher temperature than do those of the right, the difference amounting on the average to .74°. Moreover, the range from maximum to minimum at the lateral stations on the right is larger than it is on the left, being on the average 6.25° on the left and 7.58° for the right, showing a preponderance in favor of the right of 1.33°. It will also be remarked that the temperature of the brain decreases posteriorly, with the single exception of the Left Parietal Station, of which the average is .04° higher than that of the next highest point, the Left Frontal. In this last particular my observations differ from those of M. Broca. Has the connection between the third left frontal convolution and the memory and faculty of language anything to do with this phenomenon? I am inclined to think that it has. M. Heftler* states that the lower portion of the fissure of Rolando is 28 millimetres, or about $1\frac{1}{11}$ inch, to the rear of the fronto-parietal suture. It has been at or rather anteriorly to this point that my Parietal Stations have been situated, so that they have actually been over or in close proximity to the third frontal convolution at its upper and posterior part, where it is bounded by the lower portion of the fissure of Rolando. The memory of words and the faculty of articulate language, to which the structural integrity of the third left frontal convolution is known to be necessary, are so interwoven with all forms of mental activity, as thought and the emotions, that it is by no means a bald hypothesis to suppose that this convolution may have a more incessant and complicated function to perform than any other portion of the brain.

The maxima and minima of temperature at the lateral stations were as follows:

Op. cit.

	Maximum.	Minimum.	Difference.
Left Frontal	97°	91°	6°
Right Frontal	97°	89.75°	7.25°
Left Parietal	96.50°	90°	6.50°
Right Parietal	97.50°	89.50°	8°
Left Occipital	95°	88.75°	6.25°
Right Occipital	95.50°	88°	7.50

The average range from the maximum to the minimum was 6.91°.

The average of the whole of the left side of the head was 93.83°, of the right 92.92°, there being a difference of .91°. The maxima and minima ran thus :

	Maximum.	Minimum.	Difference.
Left side	96°	90.83°	6.83°
Right side	95.25°	90°	5.25°

The average range of the sides of the head from maximum to minimum was 6.04°.

The average of the whole head, exclusive of the vertex, was 93.51°, the maximum 96.09°, the minimum 89.75°, the range 6.34°.

The average of the temperatures taken in the mouth was 99.68°, the maximum 100.50°, while the minimum was 99°. This average is somewhat higher than it is generally supposed to be, and yet it is in striking accord with that obtained by Dr. J. Davy,* in his series of researches upon 114 subjects of both sexes, of different ages, among various races and latitudes, and with various atmospheric temperatures. His mean was 100°, the highest temperature 102°, the lowest 96.50°. It is a curious coincidence that the mean temperature of the atmosphere in his investigations was about the same as in mine. Of this I feel quite positive, although I have no exact notes of this factor in my own cases.

The temperature of the vertex was taken in persons whose

*Carpenter's *Physiology*, edited by Francis G. Smith, M. D. : Philadelphia, 1876, p. 529.

hair was decidedly thin, or who were bald. The hair at the sides need only be encountered at the Occipital Stations. At the brow and above the ear the thermometer can always be placed directly upon the skin; and even at the occiput the hair can be pushed to one side to so large an extent as to interfere but slightly with the result, as I shall presently endeavor to show. At the vertex, however, the hair is usually very much thicker, longer, and more difficult to dispose of, rendering observations of the kind of which I am treating extremely variable and uncertain. I regret to state that for these reasons my cases have been limited to 13—too small a number upon which to base positive conclusions, but which I hope to supplement at some future day with others. I have not thought it worth while to detail the temperature at the four individual stations, nor of those to the left and right of the great longitudinal fissure, as they are all too closely approximated to render this procedure of any value, but rather to calculate the average of the whole vertical quartette. This was 91.67°. The maximum stood at 94.50°, the minimum at 83.37°, the range from maximum to minimum being 6.13°.

The temperature of the whole head, inclusive of the vertex, was 92.66°, the maximum 95.02°, the minimum 90.67°, the range from maximum to minimum 4.35°.

I have endeavored to ascertain what difference was effected at the Occipital Stations by the hair. I have, therefore, compared the temperature at these spots of thirteen thin-haired persons with the temperature at the same points in thirteen thick-haired individuals. In those with thin hair the average on the left was 92.62°, standing at 92.11° on the right. The thick-haired possessed an average on the left of 92.19°, on the right of 91.38°. The average elevation of temperature obtained in the thin-haired above those whose hirsute covering was more abundant was .58°, or slightly above one-half of one degree.

The effect of mental exercise upon the temperatures has been exceedingly variable. My observations only number four, and I do not cite them to demonstrate a general law, which can only be established by more extended study, but simply to contribute in some slight degree to this study. In the first

of my subjects, a very intelligent physician, after reading ten minutes, the only rise was one of .50° at the Right Parietal Station. In the second person, a young student, ten minutes' reading produced an elevation of .75° at the Left Parietal Station, and one of .50° at the Right Frontal. My third case, an eminent physician of an active and profound mind, was tested after a vivacious lecture, and yielded the following figures: A decrease of 1.67° at the Left Frontal, an increase of 2.50° at the Left Parietal. On the right side there was an increase at each of the three Stations amounting to .67° at the Frontal, to 1° at the Parietal, to 2.50° at the Occipital. Yet the average of the whole left side amounted to .98°, whereas that of the whole right descended .28°. The average of the whole head, however, exclusive, of course, of the vertex, which was not taken into account for this purpose, was raised .25° by the lecture. The fourth observation varies still more remarkably. It was made upon a distinguished professional gentleman, who is a well-known writer and an active lecturer, and was taken after a lecture delivered in the full tide of a medical term. On the left side the Frontal and Occipital Stations fell .25° and 2° respectively, and the Parietal rose .50°. The Right Frontal rose .50°, the Parietal 1°, while the Occipital fell off .75°. The average of the left side was .69° higher after the lecture, whereas that of the right was .25° lower. But the average of the whole head was elevated 1.17°. The averages computed from these figures showed, nevertheless, that the psychical labor had increased the actual evolution of heat in general, however much it might vary at particular points, the average of the whole head having ascended .14°, the average of the left side .19°, the average of the right side .07°. In this connection I desire to call attention to a fact lending support to the theory which I have advanced in regard to the relative functional activity of the third left frontal convolution. In three of these four cases there was an elevation of temperature at the Left Parietal Station of from 2.50° to .50°; the average ascent of the four subjects was thus .89°. In other words, there was very generally, so far as these scanty figures show, an increased amount of caloric given off in the neighborhood of the third left frontal convolution, and the average of this

amount was greater than the average of the increase at any other point.

These observations tally in many respects with those of M. Broca. He states the average of the left and right sides to be respectively 93.20° and 93.02°, while my figures are for the same points 93.83° and 92.92°, standing .63° more on the left and .10° less on the right. Again, according to him, the average of the whole head is 92.87°, and the maximum and minimum are affirmed to be each 94.75° and 91.04°. I found this average to be 92.66°, or .21° lower than he did, and the maximum and minimum to be 95.02° and 90.67°, or .27° higher in the former and .37° lower in the latter. These variations are so trivial that they may readily be explained by the great disproportion between the number of M. Broca's cases and my own. Indeed, to my mind, the difference is so slight that I even deem it worthy of being regarded as evidence of the remarkable uniformity of the cerebral temperature. I cannot look upon it as a mere coincidence that the temperature of twelve young men, who were selected for experiment with great precautions as to similarity in age, intellect, and surroundings, should approximate so closely to the temperature of 102 individuals, who were purposely selected, so to speak, with carelessness.

It will have been observed that the range from the maximum to the minimum temperature is a large one when compared with that of the axillary or buccal temperature. For instance, in my cases the buccal temperature ran over a scale of 1.25°, the maximum rising to .58° above, while the minimum was .68° below the average. In the cerebral temperatures, on the other hand, the average range at the lateral stations was 6.91°, while at the vertex it was 6.13°. *A priori* it might well be supposed that the production of heat within the cerebrum would fluctuate within much wider limits than it would in the body. The wonderful complexity of the function of the brain; its almost ceaseless activity; the ease with which it is animated or depressed by innumerable internal and external influences; the manifest provision for normal fluctuations of the vascular supply within comparatively wide limits,

as is evidenced in the greater amount of contractile fibre in the cerebral arteries relatively to the peripheral vessels, as well as in the arterial expansion which is permitted by the peri-vascular spaces: all point to this organ as one in which the molecular changes proceed with unrivaled vivacity and variability, and in which the evolution of heat whould be characterized by equal rapidity and variation. Can we then in the face of this large range of the temperature of the normal brain from maximum to minimum, make any diagnostic use of the thermometer? Let the ensuing figures answer this question. In 61.84 per cent. of the observations, the temperature stood either at the average, or from 1.13° above to 1.14° below. In 77.95 per cent. of the cases, the temperature was either at the average, or from 1.64° above to 1.70° below. In 86.23 per cent. of the personages examined, the temperature was at the average, or from 2.13° above to 2.26° below. In 64.33 per cent. of the cases, the temperature at each of the lateral stations on the left was higher than that of the corresponding stations on the right. In 10.33 per cent. the temperature at each of the lateral stations on the left was the same as at the corresponding stations on the right. In 25.33 per cent. of the cases, the temperature at the lateral stations on the right was higher than at the corresponding stations on the left. The average of the whole of the left side was higher than that of the right in 70 per cent. Finally, the average of the whole of the right side was higher than that of the left in 30 per cent. *In other words, when the temperature goes beyond one and a half degree above or below the average, there will be only* 22.05 *persons in every hundred in whom it would be normal; when the temperature surpasses about two degrees above or below any average, there will be only* 13.77 *individuals in a hundred in whom this temperature would be normal; and only* 25.33 *persons out of a hundred will display a higher temperature at any station on the right side than at any corresponding station on the left.*

In view of all these facts, I feel myself warranted in drawing the following conclusions:

1. The average temperature of the Left Frontal Station is 94.36°, the Right being 93.71°.

2. The average temperature of the Left Parietal Station is 94.44°, the Right being 93.59°.

3. The average temperature of the Left Occipital Station is 92.66°, the Right being 91.94°.

4. The average temperature of the left side of the head is 93.83°, the right being 92.92°.

5. The average temperature of the whole head, exclusive of the vertex, is 93.51°.

6. The average temperature of the motor region of the vertex is 91.67°.

7. The average temperature of the whole head, inclusive of the vertex, is 92.66°.

8. If there be an alteration of temperature at any of the lateral stations of more than one and a half degree above or below the average temperature of such station, this fact will justify a *suspicion* of abnormal change at that point.

9. If there be an alteration of temperature at any of the lateral stations of more than two degrees above or below the average of such station, this fact will constitute *strong evidence* of the existence at this station of abnormal change.

10. In proportion as the alteration of temperature at any individual station is increased or decreased beyond the figures just mentioned, in exact proportion will the strength of the evidence be increased as to the existence of abnormal change at that station, until, the maximum or minimum having been passed, the evidence will become almost conclusive.

11. Should it so happen that such elevation of temperature above the average should be at any lateral station on the right, causing a rise at this point beyond the average temperature at the corresponding station on the left, this would strengthen the suspicion or the evidence.

12. These remarks apply with equal force to the average for the whole of either side, as well as to the average for the whole head.

13. It is necessary to the validity of these conclusions that the contemporaneous bodily temperature should be normal, or that there should be a marked disproportion between it and the cerebral temperatures.

Through the kindness of my friend, Dr. Frank W. Rockwell, of Brooklyn, I have been enabled to test the value of these deductions in a very interesting case of tumor of the brain, which I was courteously permitted to report to the New York Neurological Society, at its meeting on June 3d of this year, and of which Dr. Rockwell will soon publish a full account. The patient was a female, aged thirty-four. There was present a typical "choked disk," marked pain in the temple and brow, becoming unbearable in paroxysms, nausea, vomiting, ptosis, paralysis of the ocular muscle. The first paroxysm of pain came on January 21st. The bodily temperature ranged near the normal. Upon these symptoms a diagnosis of intra-cranial tumor was made, probably situated at the base. Placing my thermometers upon the head, I ascertained the temperature at the different stations to be as follows:

	Left.	Right.
Frontal	96.75°	98.33°.
Parietal	95°	99.75°.
Occipital	96.75°	100.50°.

The average of the two sides, if calculated, will be found to be 96.16° on the left, on the right 99.52°, the average for the whole head being 97.84°.

The rise above the normal averages is startlingly apparent. At the Left Frontal Station it was 2.39°; at the Left Parietal, .56°; at the Left Occipital, 4.09°; at the Right Frontal, 5.12°; at the Right Parietal, 6.16°; at the Right Occipital, 8.56°; while the average of the left side had mounted above the normal 2.33°, the right side 6.60°, and the average of the whole head 4.33°!

This particular observation was taken as I was at the outset of my study of the subject, and was made with my first set of thermometers, which, as I have already stated, were defective. I have satisfied myself, however, that the defect amounted to but a little over one degree. If, therefore, from these figures one and a half degree be deducted, all fear of error may be dismissed; and yet the increase is unmistakable. About this date (March 4th), I wrote Dr. Rockwell: "I shall certainly expect to see inflammatory changes from the base of

the fissure of Sylvius backward along the occipital lobe, as well as that these changes shall be spread around the base of the fissure." The patient died March 16th. At the *post-mortem*, at which, much to my regret, circumstances prevented my attendance, there were present Drs. Rockwell, Arthur Matthewson, and E. S. Bunker. The meninges were found apparently normal, with the exception of a slight congestion. At the base of the brain the membranes and skull were to all appearances healthy. But a soft, jelly-like tumor, the size of a hazelnut, was found between the horizontal or posterior branch of the fissure of Sylvius and the first temporal fissure, while the whole of the right occipital lobe was converted into a colloid, extremely vascular mass, which gave way under examination, this degeneration also extending anteriorly to the tumor as far as the fissure of Sylvius. There was no apparent disease except at these points. Upon microscopical examination, I ascertained the tumor to be a typical glioma, thickly strewn with small extravasations of blood.

This is, I believe, the first case on record in which a diagnosis of the locality of an intra-cranial morbid growth has been made with a thermometer, and afterward verified by a *post-mortem* examination.

I cannot resist the conviction that these data are sufficient to enable the profession to employ the thermometer with profit in the diagnosis and localization of cerebral affections. I trust that experience will substitute proof for my conviction. I am now engaged in the study of the pathological aspect of this question. My material is not yet ripe for publication, but I expect at some future day to be able to communicate to the profession further details as to the exact possibilities of this subject.